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A complex study of different metal sorption mechanisms onto contrasting biochars

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Abstract
The main objective of this study was to compare different biochars for the removal of Cd and/or Pb from aqueous solution. In more detail, different Cd and Pb sorption mechanisms onto these contrasting biochars were determined. Five different waste agro-materials were chosen for the biochar preparation using pyrolysis at 600 °C: nut shells (NS), wheat straws (WS), grape stalks (GS), grape husks (GH), and plum stones (PS). Laboratory batch sorption and desorption experiments were implemented to test the efficiency of all biochar samples. Next, pure and metal-loaded biochar samples were analysed using FTIR, SEM-EDX and XPS analyses to understand metal sorption mechanisms. Results showed that metal sorption efficiency of Cd and Pb decreased in the order: PS > NS > GH > WS > GS. Additionally, the consecutive removal efficiency using different leaching solutions was minimal for the GS and maximal for PS and NS biochars. These differences are caused by varying metal sorption mechanisms: NS as well as PS are predominately mechanically sorbed or precipated on the biochar surface. There is only a single weak metal bindings with carbon; hence desorption was maximal for this case. On the other hand, metals are strongly fixed onto/into the GS biochar (= chemical sorption) due to metal chelate formation together with carboxylic/carbonyl functional groups or due to cation (K+, Ca2+ and Mg2+) release.

Keywords
Metal binding; cations release; metal chelate; physical adsorption; surface precipitation